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April 29, 2021

Todd Slater
Legacy Site Services LLC
665 Stockton Drive, Suite 100
Exton, PA 19341

Subject: Pre-Final Design Report
Arkema Facility, ECSI No. 398

Dear Mr. Slater:

The Oregon Department of Environmental Quality received the *Pre-Final Design Report* (Design Report) dated March 17, 2021. Environmental Resources Management (ERM) prepared the report for Legacy Site Services LLC (Legacy). The Design Report documents activities actions to be performed to enhance groundwater extraction to improve hydraulic capture of the groundwater extraction and treatment system (GWET) system and associated barrier wall.

The GWET system and associated barrier wall represent the primary method of groundwater contaminant source control at the Arkema site, a high priority project in the Portland Harbor Superfund Site. The GWET system is a hydraulic containment system designed to prevent contaminated groundwater behind the slurry barrier wall from migrating to the river. The wells must extract groundwater at rates greater than or equal to the groundwater flux through the alluvial water bearing zones lying immediately upgradient of the wall to be effective. The performance criteria for the GWET system and barrier wall is: 1) inward hydraulic gradients, and 2) an absence of mounding behind the wall. Although, neither of these performance criteria have been achieved, the criteria remains the primary lines of evidence in evaluating source control performance. The GWET system's current configuration has not achieved or sustained the required inward gradients. Migration of contamination around and possibly under the wall remains an ongoing concern. The success of the proposed modifications in gaining hydraulic control will be critical to determining if the GWET system and barrier wall are an effective source control during the preparation of the upland Feasibility Study later this year.

General Comments

1) Include a section that presents start up details, process to optimize pumping rates, and impacts to the treatment train. Include discussion on actions that will be taken in the event vertical migration of dense non-aqueous phase liquid (DNAPL) occurs.

Specific Comments:

1) **Section 3**. The GWET design report describes significant changes to the numerical model originally developed for the Arkema site in 2007 including a site-wide reduction in hydraulic conductivities by a factor of 10. Although some information on model calibration is included in the report, documentation and validation of the model changes are insufficient for DEQ to approve or concur with the model results. DEQ views the model as a design tool for internal use by ERM and LSS. DEQ will continue to rely on

empirical data collected form the monitoring well network to evaluate the effectiveness of containment.

2) **Section 3.1.1.** In DEQ's experience the highest groundwater flux periods do not coincide with the high or low river stage but occur when the upland groundwater to surface water hydraulic gradients are at a maximum, usually late spring on the lower Willamette. In regards to performance, DEQ expects the GWET system, if capable, to maintain inward gradients (based on Serfes Averages) continuously throughout the year. Therefore, both the extraction and treatment system will need sufficient capacity to absorb peaks in groundwater flow. DEQ requests the current estimate of treatment plant capacity and how this compares with estimated peak groundwater extraction rates be presented.

3) **Sections 4.4.3.** Provide a description of the logic parameters that will be programed into the system to control pumping rates at each trench.

4) **Section 4.5.** Some of the proposed trench alignments may encounter debris during construction. The design should present measures that will be taken if excessive debris is encountered during excavation activities. If significant debris is encountered that warrants relocation of a trench or backfilling large void space areas outside of the trench footprint, DEQ should be notified prior to performing the action.

5) **Section 4.5.** Describe material handling requirements for materials excavated from each trench, including on-site staging/stockpiling, waste characterization, and disposal requirements.

6) **Section 4.5.** Describe the actions that will be taken, including DEQ notification, in the event that DNAPL is identified or encountered in borings or during trench construction.

7) **Tables 3a and 3b.** The modeled vertical and horizontal gradient in Table 3b provide good numerical criteria to evaluate performance. Confirm these points will be monitored continuously over the year to evaluate gradient variability over time and the adequacy of the target gradients will be re-evaluated after a year of operation to assure they align with containment objectives.

8) **Figures 2, 3, 6, 7, & 8.** Include the DNALP plume on the figures.

9) **Appendix D, Step 3.** Review friction head loss calculations for stainless steel and PVC pipe. Calculated results appear to reference incorrect friction factors (i.e., the friction head loss calculation for stainless steel appears to reference the friction factor for PVC and vice versa).

10) **Appendix D, Step 6.** Describe the method(s) and equation(s) used to calculate head loss through each pipe segment. If the Hazen-Williams method is used, include the Hazen-Williams coefficients assumed for PVC. If Darcy-Welsbach method is used, present estimated Reynolds numbers and friction factors for each pipe section.

11) **Appendix E, Sheet 4.** Show and label stockpile areas 1, 2, and 3, which are described in Note 5.

12) **Appendix E, Sheet 5.** Provide construction details for temporary storage areas 1 and 2.

EPA has reviewed the Design Report. EPA's comments are enclosed. EPA's comments should be taken into account, as appropriate.

Please contact me at 503-860-3943 or by email at Katie.Daugherty@deq.state.or.us if you have any questions.

Sincerely,

Katie Daugherty

Katie Daugherty, R.G.
Project Manager
NWR Cleanup & Tank Program

Enclosure (EPA Comments)

cc: Administrative File
ecc David Lacey, DEQ
Madi Novak, EPA
Ben Leake, EPA
Brendan Robinson, ERM
Josh Hancock, ERM
Sarah Seekins, ERM

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SUPERFUND &
EMERGENCY
MANAGEMENT DIVISION

MEMORANDUM

DATE: April 29, 2021

SUBJECT: Pre-Final Design Report
Arkema Inc. Facility, Portland, OR
ECSI #398
March 17, 2021

FROM: Benjamin Leake, PMP BJL
Remedial Project Manager

TO: Katie Daugherty, R.G.
Project Manager
Oregon Department of Environmental Quality

Following are U.S. Environmental Protection Agency (EPA) comments on the March 17, 2021 document, *Pre-Final Design Report, Arkema Inc. Facility, Portland, Oregon* (PFDR). This document was prepared by ERM-West Inc. on behalf of Legacy Site Services, LLC (LSS).

The former Arkema Portland Plant (site) is located at 6400 NW Front Ave in Portland, Oregon. The site is listed in the Oregon Department of Environmental Quality (DEQ) Environmental Cleanup Site Information (ECSI) as #398, located at River Mile 7.2 West (RM 7W), on a riverbank listed in the Portland Harbor Superfund Site Record of Decision, and is considered by DEQ and EPA as a high priority for groundwater source control.

EPA understands the PFDR updates the conceptual design of the proposed system of groundwater recovery trenches to an approximately 90 percent complete design (i.e., Pre-Final Design), and provides additional details regarding the design as requested by the DEQ and EPA in comments provided on the Draft PDI on January 5, 2021. EPA's review focuses on the conceptual design to ensure that the proposed recovery trench is appropriately designed and addresses fouling issues that have limited past groundwater recovery efforts.

EPA comments are provided as "Primary," which identify concerns that must be resolved to achieve the assessment's objective; "To Be Considered," which, if addressed or resolved, would reduce uncertainty, improve confidence in the document's conclusions, and/or best support the assessment's objectives; and "Matters of Style," which substantially or adversely affect the presentation of the technical information provided in the report.

Primary Comments

1. To best meet the design objectives, the final design report should identify a design component and/or operational aspects that will mitigate the inherent fouling of the extraction trenches. Alternatively, the final design report should include a means to rehabilitate the extraction trenches on a regular basis, to prevent fouling that diminishes performance in a manner similar to the recovery wells at the site. The design should include such functional component because the groundwater extraction process inherently introduces air/oxygen into the subsurface, which will oxidize compounds such as iron and promote biological growth.

To Be Considered Comments

1. To document that the proposed design will best achieve the objectives, the final design should be supported with a quantitative evaluation of the trench design using the geometric mean of the hydraulic conductivity (K value) compared to the average K value presented in the PFDR. Because K is log normally distributed, the geometric mean of the K value should be used to assess the central tendency of this parameter (Freeze and Cheery 1979). Details below explain the basis of concern for the method used in the PFDR. In Sections 2.2 and 3.3 and in Tables 2 and 4 in the PDI in Appendix A, the arithmetic mean (average) of the hydraulic conductivity (K) values determined using grain size analysis are presented. The average K values are used in the analytical solution discussed in Sections 3.2 through 3.4. In the Shallow Zone the average K is 37 ft/day whereas the geometric mean K is 7 ft/day. In the Shallow-Intermediate Zone the average K is 1.41E-02 ft/day whereas the geometric mean K is 9.13E-03 ft/day (note that both values round to 0.01 ft/day). In the Intermediate Zone the average K is 24 ft/day whereas the geometric mean K is 11.5 ft/day. There are only two grain size K values in Table 4 in the PDI for the Deep Zone, so the average and geometric mean are not useful estimates of the central tendency of K for this unit. As shown here, the geometric mean value of the Shallow Zone is 19% of the average value, the geometric mean value of the Shallow-Intermediate Zone is 65% of the average value, and the geometric mean value of the Intermediate Zone is 48% of the average value presented in the report and used in the analysis.

2. Use of grain size analysis to estimate K does not provide a robust design and increases uncertainty whether the design can achieve the objectives. The final design needs to document whether slug tests or an aquifer pumping test were used to estimate aquifer properties including K, transmissivity (T), and storativity (S)or provide site specific empirical data for aquifer properties to justify the proposed K values. Given that the trench system must perform well to achieve remedial objectives, justification is needed that K determined with grain size analysis is sufficient.

3. Compiled as Attachment A are groundwater modeling comments from review of Sections 1 through 3. These comments should be adapted as needed to refine the groundwater model in the final design report to provide robust assumptions as the basis for the final design of the groundwater recovery trenches.

4. Section 2.2: The average K values shown in the table embedded in the text in Section 2.2 do not match the values in Table 2 in the PDI included in Appendix A. The Shallow Zone K in the table embedded in Section 2.2 is 37 ft/day and in Table 2 in the PDI it is 3.69 ft/day. The Intermediate

Zone K in this table is 24 ft/day embedded in Section 2.2 and in Table 2 in the PDI it is 2.39 ft/day. In addition, the values in Table 2 in the PDI are not labeled as averages. In contrast the K values for the Shallow-Intermediate Silt Zone and the Deep zone in the table embedded in Section 2.2 match the values in Table 2 in the PDI report. On the other hand, the values of average K in Table 4 in the PDI report match the values embedded in the table in Section 2.2. It appears that the difference is because the scientific notation was omitted from the values in Table 2 in the PDI for the Shallow Zone and Intermediate Zone. Please review Table 2 in the PDI and correct it as necessary.

5. Section 3.1.1: The section presents six changes in hydraulic conductivity (K) values reduced by an order of magnitude but does not describe where the changes were applied. Clarify which units or layers in the model were affected by the changes.

6. Section 3.2, last paragraph: "The flow of groundwater into the trench from the ends of the trench or through the low conductivity layers is minor, and excluding these contributions provides a level of conservativeness to this assessment." Excluding flow from the ends of the trench and the low conductivity units will underestimate flow into the trench. Including flow from these sources would, therefore, be conservative.

7. Section 3.2: Please explain the purpose of the using the analytical solution.

8. Section 3.3: In the table embedded in the text the distance to the constant head boundary is set to 400 feet. Review of Figures 7 and 8 indicates the model predicts significant drawdown 400 feet south of the trenches. Please explain the basis for setting the distance to the constant head boundary is set to 400 feet.

9. Section 3.4: The table embedded in the text lists combined flow rates from each trench which total to 213.6 gpm which is more than four times the total flow from the trenches of 54.6 gpm calculated with the model (Table 2a). Clarification should be provided whether this indicates that the flow from the trenches may be much higher than 54.6 gpm.

10. Section 4.4.1: The flow rates listed in the table embedded in the text are, except for the Trench 5 flow rate, the "high stage" rates from Table 2a. Why not use the higher, "low stage" trench flow rates from Table 2b, totaling 57.2 gpm, and the Recovery Well flow rates from Table 2a, totaling 7 gpm, and assume a higher overall flow rate of 64.2 gpm to be conservative?

11. Section 4.4.1: An explanation should be provided as to how the results of the analytical model shown in Section 3 were used in the trench design.

12. Appendix E Drawings, Sheet 8 (and others), Trench 3 Profile: Note 6 instructs contractor to use a minimum of 12 inches of select backfill as bedding. The specification for the select backfill/bedding should be provided and reference to "equivalent" material from known local sources should be included in the note.

13. Appendix E Drawings, Sheet 15. Process & Instrumentation Diagram: EPA anticipated that a future deliverable would provide the control logic and details of the pumping strategy for the in-well

pumps, presumably to be based on water levels indicated by the in-well transducer and/or flow rates. One area of interest is the extent to which the treatment plant can handle variable flow rates.

<u>Matters of Style Comments</u>

1. Section 2.1: This section introduces the stratigraphic units. Suggest a reference to Figures 3 through 8 and noting that they are provided in a separate Figures section on about page 100 of the pdf.

2. Figure 10 should include a plot of the grain size distribution from locally sourced backfill to be compared to the backfill envelope. Appendix B figures seem to have the gradations from a local source, which could be shown on Figure 10.

3. Section 3: Group all the information about the analytical solution under one subsection rather than across three subsections.

4. Section 3.1.4 2nd paragraph: "The resulting horizontal and vertical gradients for each gradient control cluster are presented in Tables 2a and 2b, respectively." This is not correct. Tables 2a and 2b list well and trench flow rates. Reword the text and/or table numbering to clarify.

5. Section 3.1.4 3rd paragraph: "Detailed breakdowns of flow per existing extraction well and trench are presented in Tables 3a and 3b." This is not correct. Tables 3a and 3b list high stage and low stage vertical and horizontal gradients. Reword the text and/or table numbering to clarify.

6. Section 4.2 8th paragraph, pdf page 19: Given the significance of the backfill material and the references to known sources, the design report should include the grain size distribution of locally sourced backfill on Figure 10 so it could be compared to the backfill envelope.

7. Figure 7: Label each of the 3 panels shown to indicate which layer and time they represent. Add a north arrow and scale.

8. Figure 8: Label each of the 3 panels shown to indicate which layer and time they represent. Add a north arrow and scale.

9. Tables: It would be easier for the reader to find information if all tables were numbered, listed on the table of contents, and either embedded in the text or separate from the test. Currently some tables are embedded in the text, e.g., in Sections 2.2 and 3.3, and some are separate from the text, numbered, and listed in the table of contents**.**

References

Freeze. R. A., and J. A. Cherry. 1979. *Groundwater*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. p. 31.

Attachment A: EPA Comments on Groundwater Modeling

Pre-Final Design Report
Sections 1-3 Groundwater Modeling Review
Arkema, Inc. Facility, Portland, OR
ECSI #398; March 17, 2021

For this project, groundwater modeling and supporting analyses are used to estimate and assess:

- Remedial extraction rate - the rate of groundwater extraction required to achieve containment and hydraulic gradient targets
- Extraction spatial distribution - horizontal and vertical distribution of groundwater extraction that will efficiently and effectively meet target objectives
- Extraction design - to a lesser degree, modeling helps to identify how to achieve the groundwater extraction target (i.e., wells or trenches, how many wells, length of trenches)

Extraction Rate

The required rate of groundwater extraction is naturally closely related to the expected rate of groundwater inflow, primarily including local (i.e., over the model area) precipitation recharge and upgradient subsurface inflow from outside the model area. Recharge of surface runoff from the upgradient tributary area, local groundwater discharge to streams and evapotranspiration from shallow groundwater may also be factors.

The documentation reviewed provides little information about groundwater flows to help substantiate proposed remedial extraction rates.

Local recharge – Section 3.3 text describes model input and has a local precipitation recharge rate of 21 in/yr. is noted in the analytical trench flow computations. Although this is probably an appropriate average rate, the design does not identify the rate used in the modeling nor provides the flux over the model domain and over the remedial capture area. At minimum, the modeling text/tables should provide the specific recharge rates that were applied to represent the high water (April 2020) condition versus the low water (October 2019) condition.

Upgradient subsurface inflow – This is presumably represented by model-computed inward flux at the upgradient constant head boundary. The model-computed inflow for all simulations including, both wet and dry conditions, should be documented and checked for consistency with expected subsurface inflow rates from the upgradient watershed area. The USGS provides estimated recharge rates to the basalt hillside watershed in the following documents:

- *Description of the Ground-Water Flow System in the Portland Basin, Oregon and Washington* (McFarland and Morgan, 1996), https://pubs.usgs.gov/wsp/2470a/report.pdf
- *Simulation Analysis of the Ground-Water Flow System in the Portland Basin, Oregon and Washington* (Morgan and McFarland, 1996), https://pubs.usgs.gov/wsp/2470b/report.pdf

These rates may be modified based on specific local upgradient conditions (e.g., slope or vegetation). The distribution of upgradient basalt flux to the onsite alluvium layers and the underlying fractured/weathered basalt can be estimated based on transmissivity and gradient. An example of this can be seen in the Gasco Groundwater Modeling Report prepared by Anchor QEA and dated February 17, 2017. Since the NW Natural Gasco site is adjacent to Arkema, the water balance analyses presented in this report would be relevant.

Water budget – A comprehensive water budget should be provided for all of the simulations presented. This should include the inflow described above as well as discharges to extraction wells/trenches, local stream/surface water features and the Willamette River.

Extraction Spatial Distribution

Flow field – It would be very helpful to provide visualization of the simulated flow fields for both the verification simulations and the proposed remediation simulations. At a minimum this should include simulated head contours for key model layers. Flow/velocity vector plots and cross section plots might also be helpful.

Aquifer characterization – The proposed extraction distribution is naturally related to the aquifer structure and hydraulic properties. The hydro-stratigraphy and hydraulic conductivity distribution represented in the model are appropriately documented. See specific comments below (Related Topics) regarding hydraulic conductivity assignments.

Extraction design

In heterogeneous aquifers such as the Arkema site alluvium, groundwater models have limited ability to predict actual performance of specific proposed wells, and even trenches that can be significantly affected by very local (currently unknown) soil conditions. Given the performance experience with existing extraction wells at this site (diminished production reportedly due mainly to clogging of filter pack with fine sand and silt) it is reasonable that strong consideration has been given to utilizing trenches. Trenches intercept a much greater aquifer area/volume than wells and are therefore less susceptible to very local variations in the soil permeability. However, it should be noted that total extraction well pumping on the order of 200 gpm has been maintained at the adjacent Gasco site.

Summary of additional model documentation that could aid in refinement of the design of the proposed system of groundwater recovery trenches:

More information is would inform the assessment of the modeling results. At a minimum, the following should be considered for all simulations presented.

- Boundary parameter values, including the basis for selection
- Simulated water budgets
- Comparison of simulated inflows to estimated inflows based on watershed area and hydrology
- Simulated head contour plots

Related Topics

Hydraulic conductivity (Section 3 and Appendix A)

Extensive grain size and NMR data from borings are presented in Section 3 and Appendix A which are the basis for hydraulic conductivity (K) assignments in the model. The layer 1 K values shown in Figure 4 look to be lower than the average 37 ft/day K value estimated from the grain size analysis shown in Section 2.2 and applied in the analytical solution of trench drainage. This is appropriate because the NMR data indicated lower K than the grain size analysis.

With 22 pumping wells installed, it is surprising that there is no discussion of applying of test data from these wells to estimate aquifer hydraulic properties. Pumping test and operational data represent actual hydraulic performance of the aquifer. Numerous monitoring wells can be used for the hydraulic analysis so that the data are not skewed by pumping well inefficiency. Pumping test data can also provide useful model calibration datasets, especially for hydraulic capture assessments.

Routine flow model calibration often helps to substantiate hydraulic property estimates. That is not so much the case with Arkema model, because constant head boundary conditions are assigned at the entire model perimeter. Hence, a previous generation of this model provided results considered usable (presumably) with hydraulic conductivity assignments 10 times the current assignments.

Model verification (Section 3.1.2)

Statistically, the verification simulation residuals (difference between model simulated head and measured head targets) are greater than expected for a well calibrated flow model. The residual root mean square error (RMSE) is approximately 18 percent of the overall head range (see Figure 5). The typical target for this statistic is 5 – 10 percent. Figures 4 and 5 indicates that the model tends to somewhat overpredict head where the heads are lower, presumably near the river mostly, and under predicts head where the heads are higher.

Most significantly (from a statistical point of view at least) Figure 4 and 5 indicates that there is a cluster of 4 shallow monitoring wells where the model underpredicts the head by more than 10 feet. This suggests that there is some feature(s) of groundwater flow in this part of the site that is not represented by the model. It would be very helpful if the residuals were shown on map or cross section figures to help locate such areas of concern.

It seems likely that the large residuals occur in an area near the north end of the barrier wall where an unusual sharp rise in the piezometric surface is shown in Figure 6, cross section C-C, in Appendix A. This is called the GCC1 Localized Pressure Area and is discussed in Appendix A, Section 4.3. Modifying the model to better replicate this condition would help to support/confirm the hypothesis presented in Section 4.3 and demonstrate that the proposed remedy will likely be effective there (or not).

Attachment A: EPA Comments on Groundwater Modeling

Analytical solution of trench drainage (Section 3.2)

- Based on simulated drawdown plots (Fig 6, 7) it doesn't look like setting constant head at 400 feet is a good assumption. Setting the constant head at a greater distance would result in a lower calculated flow. Note: A scale should be included with all maps and cross sections.

- It's not clear what the Hydraulic Gradient value in the input table refers to. The gradient is not shown as a parameter in either solution presented. A constant value is shown for all trenches even though trench water levels are all different.

- Substantiation should be provided whether drawdown (10+ ft for low stage at most locations) would significantly reduce the shallow zone saturated thickness near the trenches. If so, clarification should be provided whether the calculation accounts for this.

The assumed shallow zone K of 37 ft/day, based on the grain size analysis, is high compared with model distribution shown in Figure 4.